The Effect of Static Converters on Field Grading Materials in Rotating Machines

ABSTRACT

Silicon carbide microvaristors are the most common type of stress grading materials being used for the design of coils and bars. the main objective of this project is determination of the microvaristor's response over a wide range of electric field, frequency and temperature. Unfortunately, in spite of previous research in this area, an accurate measurement method, which clears the performance of these materials in mentioned conditions, has not been addressed effectively, owing to problems arising during practical measurement such as thermal run away and response determination in high frequency. On the other hand, such types of insulations are distinctively different from conventional insulations because of Maxwell-Wagner polarisation process, originating from composite mixture of the microvaristors and matrix of insulation. This project aims to provide a viable solution for above addressed issues.

CONTACT

Reza Sargazi
Norwegian University of Science and Technology (NTNU)
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INTRODUCTION

With the introduction of transformer-less converters and their implementation in hydro-power generator systems, electric field distribution of insulation systems is drastically changed. Concerning consequential issues of converters, there are two important agents, namely voltage and temperature according to IEC standards for Type II insulation systems. These effects are summarized in Table I.

Table I. different types of stress on insulation system fed by static converters

Insulation component	Fundemental frequency	Impulse repetition frequency	peak to peak voltage of fundemental frequency	peak to peak voltage of two consecutive impulses	Impulse rise time
Turn to turn insulation	Low	High	Low	High	High
Mainwall insulation (Mica)	High	Low	High	Low	Low
Corona (CAT) and stress grading Layer (SG)	Low	High	High	High	High

Note: ● High Importance ○ Low Importance

Silicon Carbide Microvaristors

Traditionally, before the introduction of microvaristors, slot corona protection layer was used both in the slot as well as the end winding area for rotating machines above 4kV. With The advent of microvaristors in the 1970s, manufacturers could cut the corona protection layer just a few centimeters outside the slot without extension into the endwinding region. The resulting local electric field enhancment at this point was also reduced by introducing stress grading layer. this layer has a electric field dependent resistance reducing the high fields and pushing it out into the lower field areas. However, under impulse voltage stresses, its field controlling ability is influenced by factors summerised in table I. The insulation system of Roebel bars for rotating machines is shown in figure 1.

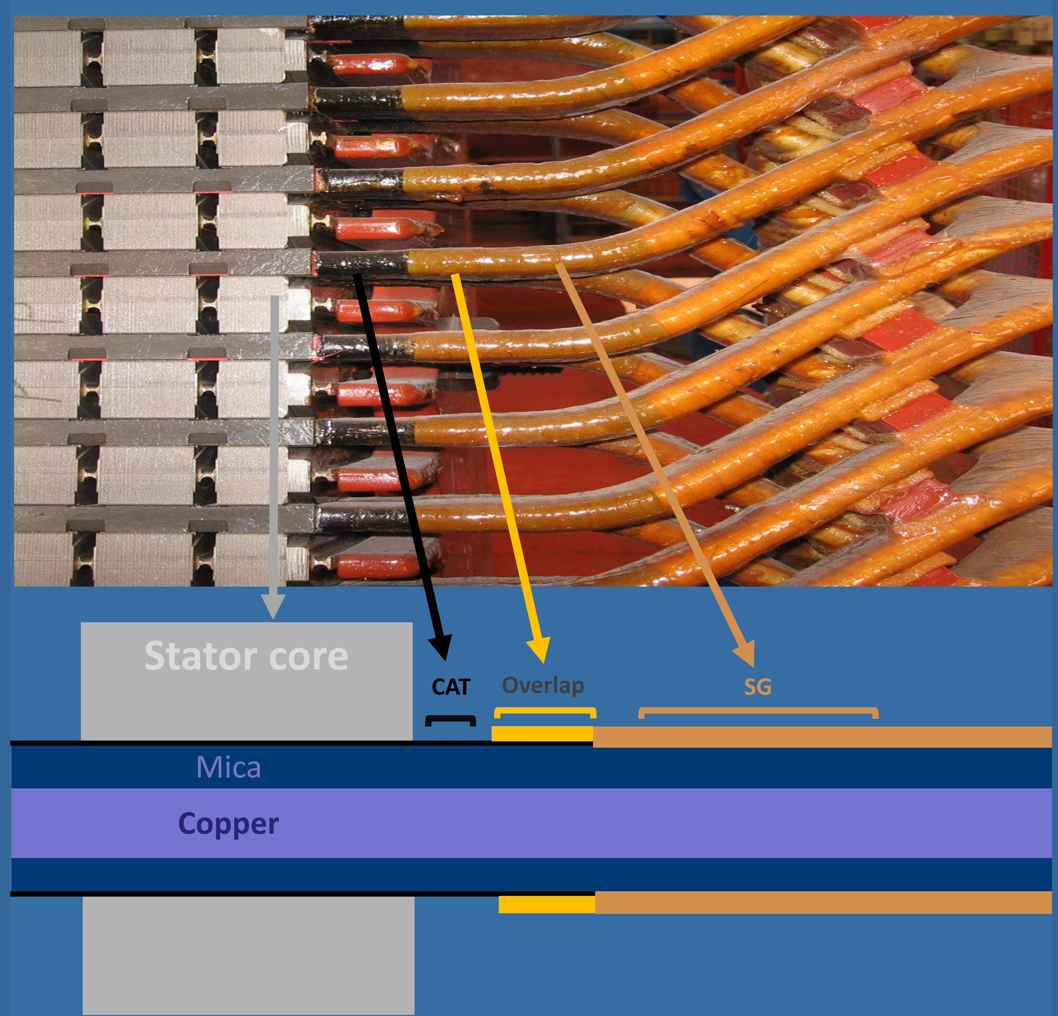


Figure 1. insulation system in Roebel bars

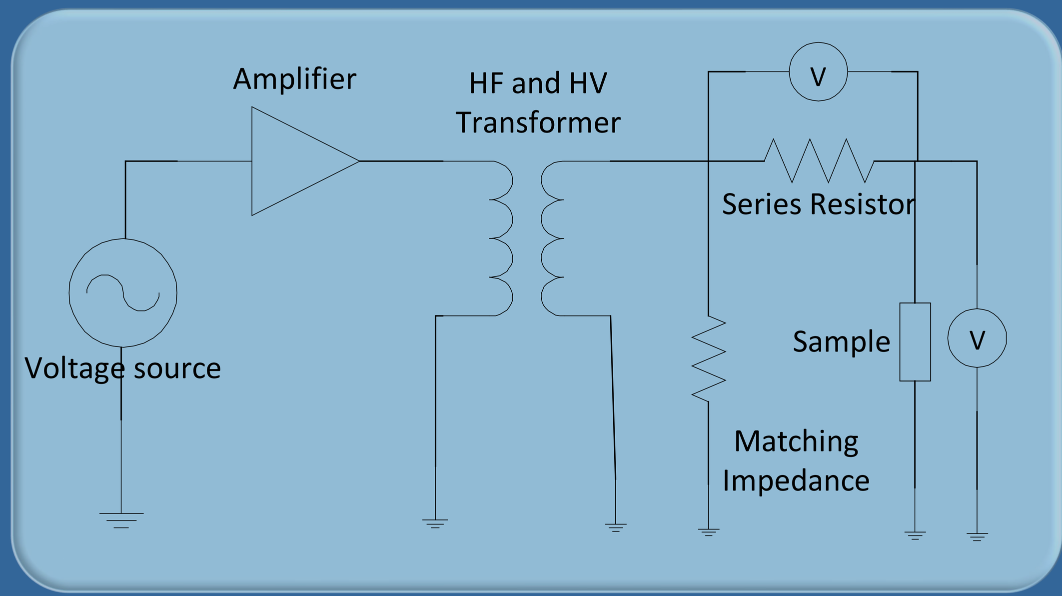
Modeling

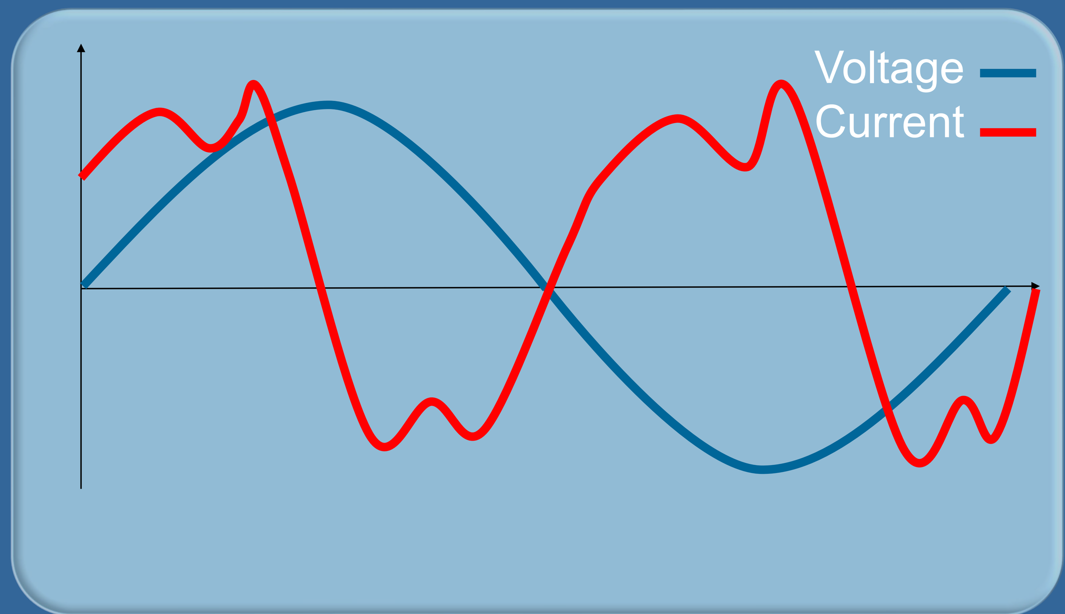
Dielectric spectroscopy

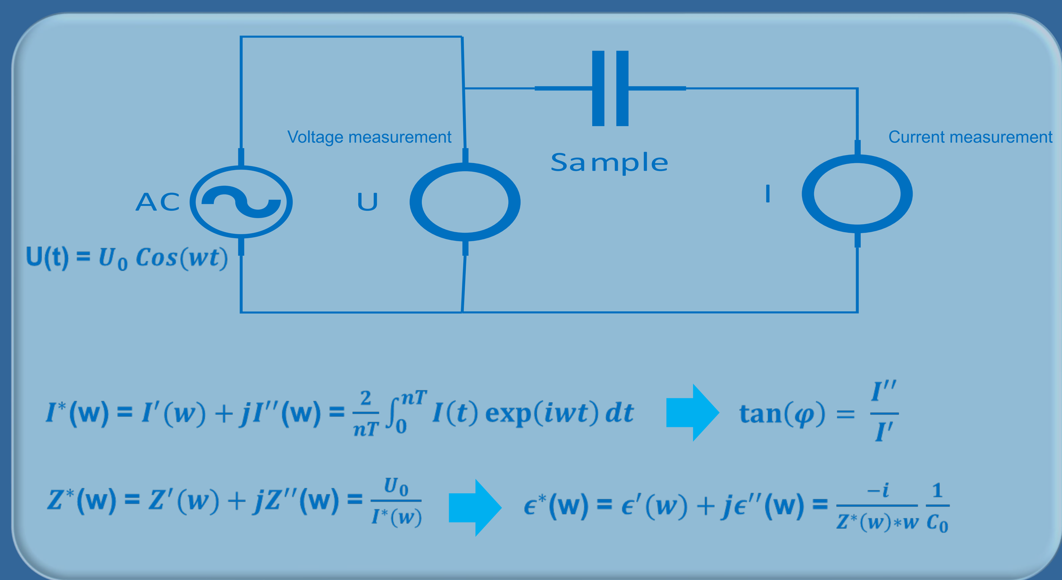
Dielectric spectroscopy of insulation is an effective method for insulation modeling. This method can be implemented both in time and frequency domain with possibility of data conversion between both domains in terms of linear dielectric materials. Generally, conductivity of dielectrics can be expressed as following equation.

$$J(t) = \sigma_0 E(t) + \frac{\partial}{\partial(t)} (\varepsilon_0 E(t) + P(t))$$

Where E(t) is applied electric field, σ_0 is DC conductivity and P(t) is polarization process. General method for frequency domain spectroscopy is shown in below hierarchy.







DISCUSSION

Two major challenges in this project are the nonlinearity and transient response of field grading materials. The transient response of linear insulation layers (including strand, mica and slot corona protection layer) can be found by frequency domain analysis and implementation of fast Fourier transform for data conversion to the time domain . However, for the nonlinear regime of insulation materials, such correlations are usually not available requiring consideration of permittivity harmonics as well. Furthermore, in order to obtain the fast response of stress grading layer, the responses of the other insulation layers are also required.

Some of objectives

The effect of pressure finger on performance of SG

The effect of mutual capacitance of bars on performacne of SG

The effect of overlapp methods and resin insulation on SG layer